Unmanned Airborne Vehicles (UAVs) for monitoring small streams and optimizing river maintenance

UAV-borne observations of water level, surface velocity and discharge

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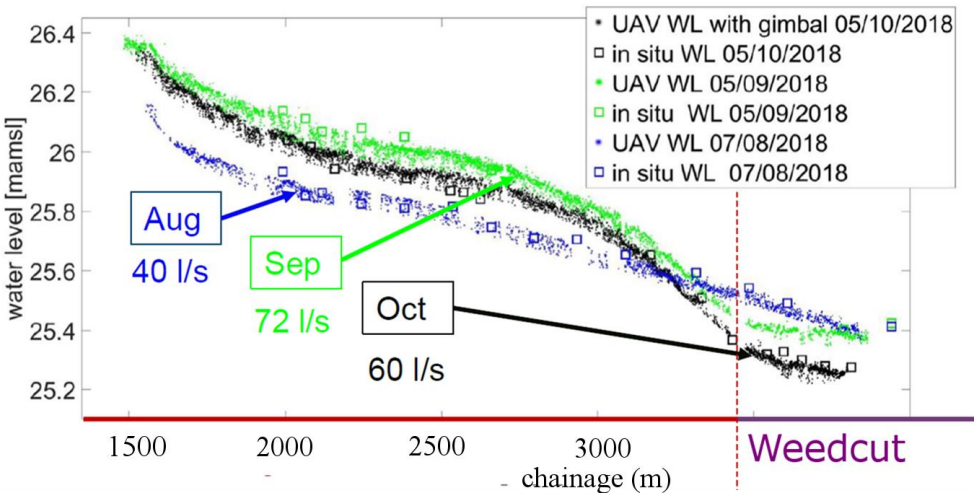
Monitoring and maintenance of Danish streams cost approx. 20-30 million USD per year. Watercourse regulations prescribe that each municipality is obliged to ensure specific cross section shape or conveyance. For this reason, ca. 20000 km of public rivers in DK must be surveyed with in-situ measurements of bathymetry and discharge every 3-10 years. These costly surveys are conducted manually and are essential for targeting river maintenance, i.e. river vegetation cutting and bottom clean-up. Maintenance operations are also detrimental to the river ecological status but are necessary to avoid floods.

In this context, more efficient methods are required to monitor rivers and optimize river maintenance. Unmanned Aerial Vehicles (UAVs) can provide high spatial resolution and dense temporal coverage data, in quick turn-around time, with waypoint-based automatic flights. To retrieve accurate UAV flight positions and angles, UAVs are generally equipped with accurate Global Position System (GPS) receivers and Inertial Measurement Units (IMUs).

A UAV, equipped with an accurate differential-GPS system and a lightweight radar chip, can monitor water level (i.e. water surface elevation above mean sea level) by subtracting the range between the UAV and the water surface (measured by the radar) from the altitude of the UAV above the geoid (measured by the GPS). Surface velocity can be estimated with Surface Structure Image Velocimetry (SSIV), a variant of image cross-correlation techniques, applied to video frames retrieved from the on-board video camera. By observing the displacements between particles, such as leaves or foam, visible on the water surface, or by observing ripples generated by water turbulence, these cross-correlation techniques can predict water surface velocity. Surface velocity observations can be used to estimate discharge by following standard EN ISO 748:2007, and by combining it with the water depth profile and a roughness coefficient.

UAV-water level observations of a stretch of Åmose Å (Denmark) are shown in the figure below. UAV-observations (in meters above mean sea level (mamsl)) showed an accuracy of ca. 3 cm when compared to in-situ Real Time Kinematic (RTK) GPS observations. These UAV observations represent a new dataset for hydrology: river water level profiles with high spatial resolution (ca. 0.5 m). River water slope is an informative dataset to understand how rivers are affected by vegetation growth and river maintenance. Indeed, water level measurements were used to calibrate a hydrodynamic model and estimate spatially distributed Manning numbers, which have a controlling influence on channel conveyance.


UAV WL with gimbal 05/10/2018
in situ WL 05/10/2018
UAV WL 05/09/2018
in situ WL 05/09/2018
UAV WL 07/08/2018
in situ WL 07/08/2018
water level [mamsl]
26.4
26.2
26
25.8
25.6
25.4
25.2
Aug
40 l/s
Sep
72 l/s
Oct
60 l/s
1500
2000
2500
3000
chainage (m)
Weedcut